Claims

1. A conductive patter comprising:

a substrate having an electrically insulating surface;

a plurality of first conductive strip halves having a given width and being arranged on the surface of the substrate such that the first conductive strip halves are separated from each other to form depressions having a given width;

a first insulating film formed on the surface of the substrate and surfaces of the depressions formed between successive first conductive strip halves;

a plurality of second conductive strip halves formed on the first insulating film such that said depressions formed between successive first conductive strip halves are filled with the second conductive strip halves;

a second insulating film formed on a portion of the surface of the substrate at which said first and second conductive strip halves are not formed ; and

a third insulating film formed on a coplanar flat surface of the first and second conductive strip halves, an end surface of the first insulting film formed on the surfaces of the depressions and a surface of the second insulating film.

2. The conductive pattern according to claim 1, wherein said first conductive strip halves includes conductive strips formed by electrolytic plating and said second conductive strip halves includes conductive strips formed by CVD.

3. The conductive pattern according to claim 2, wherein said first conductive strip halves includes conductive strips formed by electrolytic plating of copper and said second conductive strip halves includes conductive strips formed by Cu-CVD

4. The conductive pattern according to claim 1, wherein said first and second conductive strip halves includes conductive strips formed by electrolytic plating of copper.

5. The conductive pattern according to claim 1, wherein said first insulating film interposed between said first and second conductive strip halves is formed by an alumina-CVD film.

6. A method of manufacturing the conductive pattern as claimed in claim 1 comprising the steps of:

forming a plurality of first conductive strip halves having a given width on

an electrically insulating surface of a substrate such that the first conductive strip halves are separated from each other to form depressions having a given width;

forming a first insulating film on the surface of the substrate and surfaces of the depressions formed between successive first conductive strip halves;

forming a resist selectively on areas at which said first conductive strip halves are formed;

forming a second insulating film on a portion of the surface of the substrate which are not covered with the resist;

forming, after removing said resist, a conductive film such that the depressions formed between successive first conductive strip halves are filled with the conductive film;

polishing the conductive film, the first and second insulating films formed on the first conductive strip halves such that the first conductive strip halves are exposed to form a plurality of second conductive strip halves embedded in said depressions formed between successive first conductive strip halves; and

forming a third insulating film on a coplanar flat surface of the first and second conductive strip halves and the second insulating film, said coplanar surface being formed by said polishing.

7. The method according to claim 6, wherein said first conductive strip halves are formed by electrolytic plating and said second conductive halves are formed by CVD.

8. The method according to claim 7, wherein said first conductive strip halves are formed by electrolytic plating of copper and said second conductive halves are formed by Cu-CVD.

9. The method according to claim 6, wherein said first and second conductive strip halves are formed by electrolytic plating of copper.

10. The method according to claim 6, wherein said first insulating film interposed between successive first and second conductive strip halves is formed by alumina-CVD.

11. The method according to claim 10, wherein said first insulating film is formed by an atomic layer process, in which $Al(CH_3)_3$ or $AlCl_3$ and H_2O, N_2, N_2O or H_2O_2 are alternately projected intermittently at a temperature of 100-700°C under a reduced pressure state of 1-2 Torr.

12. A conductive pattern comprising:

a substrate having an electrically insulating surface;

a plurality of first conductive strip halves of a first conductive strip group, said first conductive strip halves having a second width and being arranged on the surface of the substrate such that the first conductive strip halves are separated from each other to form depressions having a first width;

a plurality of first conductive strip halves of a second conductive strip group, said first conductive strip halves having a fourth width larger than the second width and being arranged on the surface of the substrate such that the first conductive strip halves are separated from each other to form depressions having a third width larger than the first width;

a first insulating film formed on the surface of the substrate and surfaces of the depressions formed between successive first conductive strip halves of the first and second conductive strip groups;

a second insulating film formed on a portion of the surface of the substrate at which said first conductive strip halves of the first and second conductive strip groups are not formed;

a plurality of second conductive strip halves of the first conductive strip group formed on the first insulating layer such that said depressions formed between successive first conductive strip halves of the first conductive strip group are filled with the second conductive strip halves of the second conductive strip group;

a plurality of second conductive strip halves of the second conductive strip group formed on the first insulating film such that said depressions formed between successive first conductive strip halves of the second conductive strip group are filled with the second conductive strip halves of the second conductive strip group, each of said second conductive strip halves of the second conductive strip group having a two-layer structure having a first conductive film formed by CVD and a second conductive film formed by electrolytic plating; and

a third insulating film formed on a coplanar flat surface of the first and second conductive strip halves of the first conductive strip group, the first and second conductive strip halves of the second conductive strip group and the second insulting film.

13. The conductive pattern according to claim 12, wherein said first conductive strip halves of the first and second conductive strip groups include conductive strips formed by electrolytic plating.

14. The conductive pattern according to claim 13, wherein said first conductive strip halves of the first and second conductive strip groups include conductive strips formed by electrolytic plating of copper, said first conductive film of the second conductive strip halves of the first and second conductive strip groups is formed by Cu-CVD and said second conductive film of the second conductive strip halves of the first and second conductive strip groups is formed by Cu-CVD.

15. The conductive pattern according to claim 12, wherein said first insulating film interposed between said first and second conductive strip halves of the first and second conductive strip groups is formed by an alumina-CVD film.

16. A method of manufacturing the conductive pattern as claimed in claim 12 comprising the steps of:

forming, on an electrically insulating surface of a substrate, a plurality of first conductive strip halves of a first conductive strip group having a second width and being arranged such that said first conductive strip halves of the first conductive strip group are separated from each other to form depressions having a first width, and a plurality of first conductive strip halves of a second conductive strip group having a fourth width larger than the second width and being arranged such that the first conductive strip halves of the second conductive strip group are separated from each other to form depressions having a third width larger than the first width;

forming a first insulating film on the surface of the substrate and surfaces of the first conductive strip halves of the first and second conductive strip groups;

forming a covering film selectively on a region in which said first and second conductive strip groups are formed;

forming a second insulating film on a region in which the first and second conductive strip groups are not formed;

forming, after removing said covering film, a first conductive film by CVD

on said first insulating film such that the depressions formed between said first conductive strip halves of the first conductive strip group are completely filled with the first conductive film and the depressions formed between said first conductive strip halves of the second conductive strip group are partially filled with the first conductive film;

forming a second conductive film by electrolytic plating on the first conductive film such that the depressions formed between successive first conductive strip halves of the second conductive strip group are completely filled;

polishing said first and second conductive films, a portion of said first insulating film covering the surfaces of the first conductive strip halves of the first and second conductive strip groups and said second insulating film such that surfaces of the first conductive strip halves of the first and second conductive strip groups are exposed to form a plurality of second conductive strip halves of the second conductive strip group arranged in said depressions formed between successive first conductive strip halves of the first conductive strip group and made by said first conductive film and to form a plurality of second conductive strip halves of the second conductive strip group arranged in said depressions formed between successive first conductive strip halves of the second conductive strip group and having a two-layer structure composed of the first conductive film formed by CVD and the second conductive film formed by electrolytic plating; and

forming a third insulating film on a coplanar flat surface of the first and second conductive strip halves of the first and second conductive strip groups and the second insulating film.

17. The method according to claim 16, wherein said first conductive strip halves of the first and second conductive strip groups are formed by electrolytic plating.

18. The method according to claim 17, wherein said first conductive strip halves of the first and second conductive strip groups are formed by electrolytic plating of copper, said first conductive film is formed by Cu-CVD, and said second conductive film is formed by electrolytic plating of copper.

19. The method according to claim 16, wherein said first insulating film

interposed between successive conductive strips of the first and second conductive strip halves of the first and second conductive strip groups is formed by alumina-CVD.

20. The method according to claim 19, wherein said first insulating film is formed by an atomic layer process, in which $Al(CH_3)_3$ or $AlCl_3$ and H_2O, N_2, N_2O or H_2O_2 are alternately projected intermittently at a temperature of 100-700°C under a reduced pressure state of 1-2 Torr.

21. A thin film magnetic head including a substrate and at least an inductive type thin film magnetic head element supported by the substrate; wherein said inductive type thin film magnetic head element comprises;

a bottom pole made of a magnetic material which extends inwardly from an air bearing surface;

a bottom track pole made of a magnetic material which extends inwardly from the air bearing surface over a distance corresponding to a track pole;

a bridge portion made of a magnetic material and formed on one surface of the bottom pole such that a back gap is formed at a position remote from the air bearing surface;

a thin film coil formed on the surface of the bottom pole such that a surface of the thin film coil opposite to the bottom pole forms a coplanar flat surface together with a surface of the bottom track pole;

a write gap film made of a non-magnetic material and formed on said coplanar flat surface of said bottom track pole and thin film coil to have a flat surface; and

a top pole formed on a surface of the write gap film opposite to the bottom track pole and including a top track pole aligned with the bottom track pole, said top pole being brought into contact with the bridge portion;

wherein said thin film coil comprises:

a first thin film coil half having coil windings mutually separated by a given distance;

a second thin film coil half having coil windings which are formed between successive coil windings of the first thin film coil half in a self-aligned manner, at least a part of each of the coil windings of the second thin film coil half having a two-layer structure consisting of a first conductive film formed by CVD and a

second conductive film formed by electrolytic plating;

an insulating film formed to embed spaces between successive coil windings of the first and second thin film coil halves;

a first jumper wiring connecting electrically an innermost coil winding of one of the first and second thin film coil halves to an outermost coil winding of the other of the first and second thin film coil halves; and

a second jumper wiring having one end connected to an innermost coil winding of the other of the first and second thin film coil halves.

22. The thin film magnetic head according to claim 21, wherein a surface portion of the surface of the bottom pole on which the bottom and top track poles are not formed is closer to the substrate to form a trim structure.

23. The thin film magnetic head according to claim 21, wherein said top pole is formed by a two-layer structure of first and second magnetic material films.

24. The thin film magnetic head according to claim 23, wherein said first and second magnetic material films of the top pole are formed by a plating film of a magnetic material selected from the group consisting of FeN, FeCo, CoNiFe, FeAlN and FeZrN.

25. The thin film magnetic head according to claim 21, wherein each of said top and bottom poles is formed by a plating film of a magnetic material selected from the group consisting of FeN, FeCo, CoNiFe, FeAlN and FeZrN.

26. The thin film magnetic head according to claim 21, wherein said first thin film coil half includes coil windings formed by electrolytic plating of copper.

27. The thin film magnetic head according to claim 26, wherein said first thin film coil half includes coil windings formed by electrolytic plating of copper, and said second thin film coil half includes the first conductive film made of Cu-CVD and the second conductive film made of electrolytic plating of copper.

28. The thin film magnetic head according to claim 21, wherein the coil windings to which ends of the first and second jumper wirings have contact portions having a wide width.

29. The thin film magnetic head according to claim 28, wherein said first and second jumper wirings are made of a same material as that of the top pole and is formed simultaneously with the top pole.

30. The thin film magnetic head according to claim 29, wherein the contact portions of the innermost coil windings of the first and second thin film coil halves to which the ends of the first an second jumper wirings are connected are arranged side by side on a side of the bridge portion opposite to the air bearing surface.

31. The thin film magnetic head according to claim 30, wherein an insulating film is provided between said contact portions of the innermost coil windings of the first and second thin film coil halves to which the ends of the first an second jumper wirings and said bridge portion.

32. The thin film magnetic head according to claim 21, wherein a thickness of said insulating arranged between successive coil windings of the first and second thin film coil halves is 0.03-0.25 μm.

33. The thin film magnetic head according to claim 32, wherein said insulating arranged between successive coil windings of the first and second thin film coil halves is made of alumina-CVD.

34. The thin film magnetic head according to claim 21, wherein a coil winding which is closest to the air bearing surface and a coil winding which is closest to the bridge portion are formed by the outermost and innermost coil windings of the second thin film coil half, a width of the outermost and innermost coil windings of the second thin film coil half is smaller than a width of the remaining coil windings of the second thin film coil half.

35. The thin film magnetic head according to claim 34, wherein a width of the outermost and innermost coil windings of the second thin film coil half is wider than that of the remaining coil windings of the second thin film coil half by about 0.1-0.3 μm.

36. The thin film magnetic head according to claim 21, wherein the thin film magnetic head is formed as a combination type thin film magnetic head including said inductive type thin film magnetic head element and a magnetoresistive type thin film magnetic head element.

37. The thin film magnetic head according to claim 36, wherein said magnetoresistive type thin film magnetic head element is formed by a GMR head element.

38. A method of manufacturing a thin film magnetic head including at

least an inductive type thin film magnetic head element supported by a substrate; wherein a process of forming said inductive type thin film magnetic head element comprises the steps of:

forming a first magnetic material film constituting a bottom pole such that the first magnetic material film is supported by the substrate;

forming, on said first magnetic material film, a second magnetic material film constituting a bottom track pole and a bridge portion of back gap;

forming, on said first magnetic material film, a thin film coil in an isolated manner;

polishing surfaces of said second magnetic material film and thin film coil to form a coplanar flat surface;

forming a write gap film made of a non-magnetic material on said coplanar flat surface such that the write gap film has a flat surface;

forming, on the flat surface of said write gap film, a third magnetic material film constituting a top track pole and a top pole;

forming a mask on a portion of the third magnetic material film at which a top track pole is to be formed;

etching selectively said third magnetic material film such that a top track pole is formed and removing selectively a portion of the write gap film near the top track pole as well as the underlying second magnetic material film to form a bottom track pole; and

forming an overcoat film made of an insulating material on a whole surface;

wherein said step of forming the thin film coil comprises the steps of:

forming, on said first magnetic material film, a plurality of coil windings of the first thin film coil half isolated from the first magnetic material film to form depressions such that portions of the depressions surrounded by said bottom pole, bottom track pole, top track pole, top pole and bridge portion have a narrower width than the remaining portions of the depressions;

forming a first insulating film all over the first thin film coil half;

forming, on said first insulating film, a first conductive film by CVD such that said portions of the depressions formed between successive coil windings of the first thin film coil half having a narrower width are completely filled with

said first conductive film and said remaining portions of the depressions having a wider width are partially filled with said first conductive film;

forming, on a portion of said first conductive film at which the thin film coil is to be formed, a second conductive film by electrolytic plating such that said remaining portion of the depressions having a wider width are completely filled with first and second conductive films;

forming a second insulating film on a whole surface; and

polishing said first and second conductive films, first insulating film covering surfaces of the coil windings of the first thin film coil half, and second insulating film to expose the surface of the coil windings of the first thin film coil half and form coil windings of a second thin film coil half arranged between successive coil windings of the first thin film coil half;

wherein prior to forming said third magnetic material film, contact portions provided at ends of innermost and outermost coil windings of the first and second thin film coil halves are exposed, during the formation of the third magnetic material film, a first jumper wiring for electrically connecting a contact portion at an end of an innermost coil winding of one of the first and second thin film coil halves to an outermost coil winding of the other of the first and second thin film coil halves and a second jumper wiring connected to a contact portion at an end of an innermost coil winding of the other of the first and second thin film coil halves are formed with a same magnetic material as that of the third magnetic material film.

39. The method according to claim 38, wherein during said etching step, a surface of the first magnetic material film constituting the bottom pole is selectively removed to form a trim structure.

40. The method according to claim 38, wherein said third magnetic material film having a two-layer structure is formed by forming, on the write gap film, a lower magnetic material film and an upper magnetic material film successively.

41. The method according to claim 40, wherein said lower and upper magnetic material films of the third magnetic material film are formed by plating a magnetic material selected from the group consisting of FeN, FeCo, CoNiFe, FeAlN and FeZrN.

42. The method according to claim 41, wherein said second magnetic material film is formed by plating a magnetic material selected from the group consisting of FeN, FeCo, FeAlN, CoNiFe and FeZrN.

43. The method according to claim 38, wherein said first thin film coil half is formed by electrolytic plating.

44. The method according to claim 43, wherein said first thin film coil half is formed by electrolytic plating of copper, and said first and second conductive films of the second thin film coil half are formed by Cu-CVD and electrolytic plating of copper, respectively.

45. The method according to claim 44, wherein prior to forming the second conductive film by electrolytic plating of copper, a portion of the first conductive film except for a thin film forming area is covered with a resist, and after forming the second conductive film, the resist is removed to expose the first conductive film partially and an exposed portion of the first conductive film is selectively removed using the second conductive film as a mask.

46. The method according to claim 45, wherein said step of removing the exposed portion of the first conductive film is conducted by a dry etching of ion milling or high temperature RIE or by a wet etching using a diluted sulfuric acid or a hydrochloric acid or by an electrolytic etching using a copper sulfate solution.

47. The method according to claim 38, wherein said overcoat film is formed by resist.

48. The method according to claim 47, wherein said second insulating film is formed by alumina.

49. The method according to claim 48, wherein said alumina insulating film is remained between said bridge portion and said contact portions formed at the ends of the innermost coil windings of the first and second thin film coil halves, the ends of said first and second jumper wirings being connected to said contact portions.

50. The method according to claim 38, wherein said first insulating film interposed between successive coil windings of the first and second thin film coil halves is formed by alumina-CVD.

51. The method according to claim 50, wherein said first insulating film

is formed by an atomic layer process, in which $Al(CH_3)_3$ or $AlCl_3$ and H_2O, N_2, N_2O or H_2O_2 are alternately projected intermittently at a temperature of 100-400°C under a reduced pressure state of 1-2 Torr.

52. The method according to claim 38, wherein the method further comprises a step of forming a magnetoresistive type thin film magnetic head element supported by the substrate.

53. The method according to claim 52, wherein after forming the magnetoresistive type thin film magnetic head element, said inductive type thin film magnetic head element is formed.